

## The Sediment PhysicoChemical Characteristics in Sombreiro River, Rivers State, Nigeria

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### ABSTRACT:

A 24- month study aimed at assessing the physical and chemical quality of the sub- sea sediment of Sombreiro River was carried out, following field and laboratory procedures specified by standard methods. Particle size analysis of the sediment revealed that the sediment is loamy sand, with 70.29% sand, 17.31% clay and 12.39% silt. Sediment pH fluctuated from  $6.61 \pm 0.175$  –  $7.16 \pm 0.03$ , electrical conductivity ( $4798 \pm 408$  -  $10836 \pm 158$   $\mu\text{S}/\text{cm}$ ), phosphate ( $0.39 \pm 0.01$  –  $2.97 \pm 0.03\text{mg}/\text{kg}$ ), ammonia ( $0.08 \pm 0.01$  –  $1.2 \pm 0.30\text{mg}/\text{kg}$ ), nitrate ( $1.34 \pm 0.04$  –  $4.0 \pm 0.135\text{mg}/\text{kg}$ ), total hydrocarbon content ( $322.5 \pm 155$  –  $2178.5 \pm 64.5\text{mg}/\text{kg}$ ) and total organic carbon ( $0.87 \pm 0.15$  –  $2.69 \pm 0.17$ ). Sediment heavy metal loading varied from  $114.37 \pm 0.005$  –  $436.82 \pm 0.25\text{mg}/\text{kg}$  for iron,  $0.067 \pm 0.001$  –  $3.957 \pm 0.002\text{mg}/\text{kg}$  for nickel,  $0.307 \pm 0.003$  –  $7.353 \pm 0.008\text{mg}/\text{kg}$  for chromium,  $0.016 \pm 0$  –  $1.576 \pm 0.001\text{mg}/\text{kg}$  for copper,  $0.001 \pm 0$  –  $0.095 \pm 0.001\text{mg}/\text{kg}$  for cadmium,  $2.70 \pm 0.007$  –  $10.42 \pm 0.01\text{mg}/\text{kg}$  for zinc and  $0.025 \pm 0$  –  $1.424 \pm 0.17\text{mg}/\text{kg}$  for lead. The observed concentration of THC which is far above the stated limit of  $30\text{mg}/\text{kg}$  is indicative of hydrocarbon pollution in the study area.

**Key words:** Sediment, brackish water, total hydrocarbon content, mangrove vegetation, particle size analysis

### INTRODUCTION

The petroleum industry, particularly in the Niger Delta area contributes greatly to aquatic environmental degradation and pollution [1]. [2] had implicated blowouts, corrosion, equipment failure, productivity maintenance, operational errors, sabotage/and theft as the main causes and or sources of oil spills and other oil related pollutants. Oil spills pose a severe threat to the sustainability of biodiversity resources particularly fisheries and marine/coastal wildlife. [3] have reported that the major source of heavy metals in water and perhaps sediment especially in oil producing areas include crude oil, drilling fluids or mud and production water naturally occurring in the production reservoir. These metals include Vanadium (V), Nickel (N), Cobalt (Co), Cadmium (Cd), Lead (Pb), Zinc (Zn), Magnesium (Mn) and Titanium (Ti), and are capable of causing mortality to abnormal reproductive and behavioral adaptations in marine organisms [3]. On getting to the water these pollutants eventually settle at the sediment which serves as a sink of all contaminants in the aquatic ecosystem [4].

Since sediments are an important component of the aquatic ecosystem and serves as habitat and or spawning/breeding grounds for a wide range of aquatic organisms, usually referred to as benthic organisms, the maintenance of its health and by extension that of the organism it supports becomes paramount. Therefore the knowledge of the state of

health of the sediment of Sombreiro River is not just desirable but of utmost significance.

### MATERIALS AND METHODS

#### Description of the study area

The study area- Sombreiro River is located in Rivers State in the Niger Delta region of Nigeria, and lies between Latitude  $6^{\circ} 30'$  to  $7^{\circ} 0'$  E and Longitude  $4^{\circ} 12'$  to  $6^{\circ} 17'$ N [5]. It is a tidal dominated river, with possible fresh water input. The climate is classified as humid tropical of the semi hot equatorial type. The area experiences heavy rainfall from April to October with a mean rainfall estimated over 2000mm and mean annual temperature of about  $29^{\circ}\text{C}$  [6]. Recently heavy rains tend to begin by May, and even in the dry season months of November to March, sporadic heavy downpours are not uncommon. The vegetation of the river is predominantly mangrove with *Rhizophora racemosa*, *Rhizophora mangle* Gaertn and *Rhizophora harosanii* Leechman, as the dominant species [7].

#### Sampling and Sampling Techniques

Prior to actual sampling, a reconnaissance survey of the stretch of River Sombreiro was carried out, during which, 10 sampling stations were established. Sampling stations were selected based on completely randomized block design to capture all the activity spots on both sides along the coastline, (see Fig. 1).

The study area was demarcated into three blocks – lower, middle and upper blocks. Two stations (1 and 2) were established in the lower block representing the non- oil production activity zone while four stations each were established in the middle (Stations 3 – 6) and upper blocks (Stations 7 – 10). While the middle block – “legal oil production activity zone” (houses a well head and flow station) the upper block – the “illegal oil production activity zone” houses local/artisanal refineries.

Initial sampling was carried out during the reconnaissance visit, this is with the view to master field methods, get used to the sampling stations as well as equipment's and above all eliminate likely sampling/ handling errors. While the stations in the middle and upper blocks were test stations, stations 1 and 2 in the lower block served as control.

Standard methods [8] were adopted for the collection of sediment samples which lasted for 24 months.

The geographic coordinates of the sampling stations were determined in-situ with hand- held

GPS equipment – Garmin Extrex. The GPS was switched on at each station and allowed to stabilize for about 2 – 3 minutes, after which the readings were read- off and recorded.

### Sediment Samples

Two replicate seabed sediment samples for physicochemical analysis were collected in each of the sampling Station using Eckman Grab. Samples for the determination of sediment hydrocarbon/ organic content was wrapped in aluminum foil, while those for heavy metal, particle size analysis, and other parameters were kept in black polyethylene bags and transported to the laboratory for analysis. Only one sample was collected per Station for the particle size analysis.

### Laboratory Analysis

Sediment – particle size analysis as well as physicochemical/ heavy metal assessment of sediment samples for this investigation was carried out following the methods specified in the reports of [9] and [10].

Table 1: Sediment Particle Size Analysis

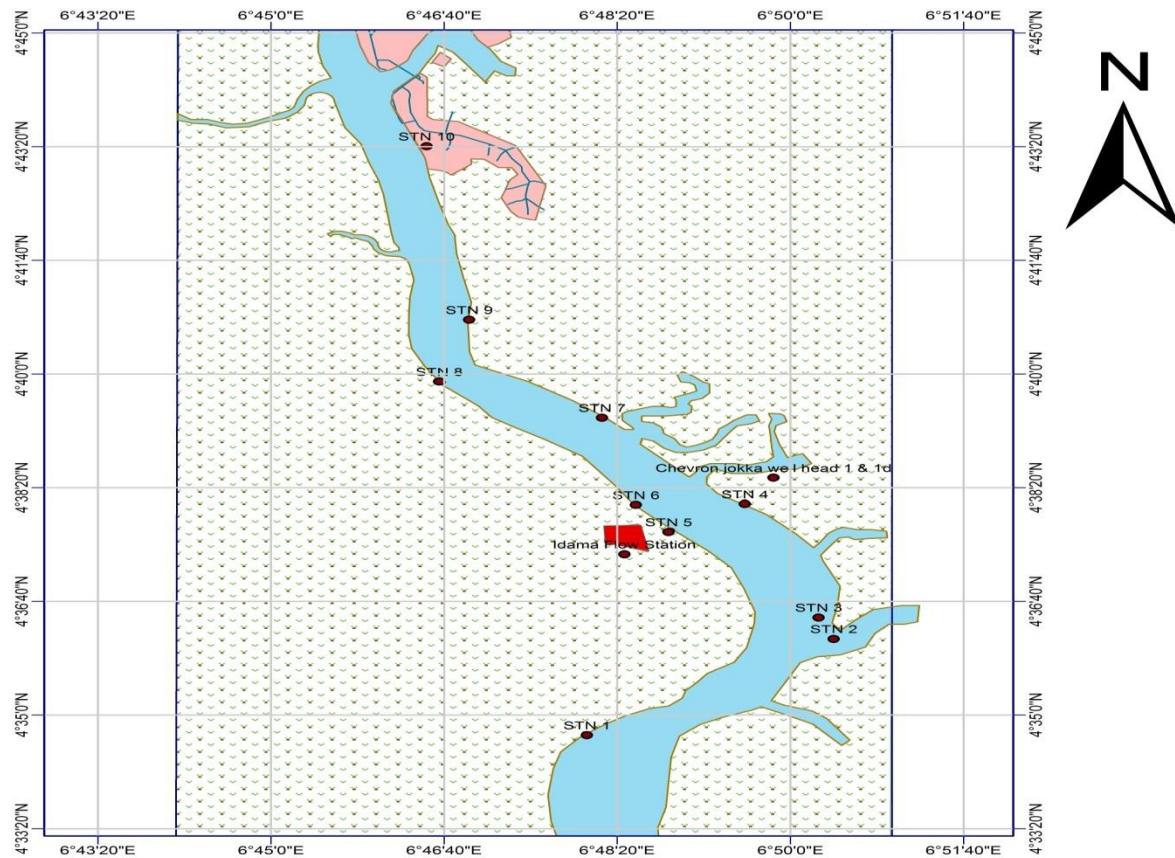
S/NO.	PARAMETER	CONCENTRATION	
		RANGE	MEAN
1.	Sand (%)	62.08 – 76.08	70.29
2.	Clay (%)	12.00 – 25.92	17.31
3.	Silt (%)	10.66 – 14.67	12.39
4.	Textural Class		Loamy Sand

Table 2: Concentration (Mean  $\pm$ SE) of Physicochemical Parameters in the Sediments of Sobreiro River

S/NO.	PARAMETER (Unit)	RANGE OF CONCENTRATION
1.	pH	6.61 $\pm$ 0.175 – 7.16 $\pm$ 0.03
2.	Electrical Conductivity	4798 $\pm$ 408 – 10836 $\pm$ 158
3.	Phosphate (mg/kg)	0.39 $\pm$ 0.01 – 2.97 $\pm$ 0.03
4.	Ammonia (mg/kg)	0.08 $\pm$ 0.01 – 1.20 $\pm$ 0.30
5.	Nitrate (mg/kg)	1.34 $\pm$ 0.04 – 4.0 $\pm$ 0.135
6.	Total Organic Carbon (%)	0.87 $\pm$ 0.15 – 2.69 $\pm$ 0.17
7.	Total Hydrocarbon Content (mg/kg)	322.5 $\pm$ 155 – 2178.5 $\pm$ 64.50

Table 3: Concentration (Mean  $\pm$ SE) of Heavy metal in the Sediments of Sobreiro River

S/NO	PARAMETER (Unit)	RANGE OF CONCENTRATION
1.	Iron (mg/kg)	114.37 $\pm$ 0.005 – 436.82 $\pm$ 0.25
2.	Nickel (mg/kg)	0.067 $\pm$ 0.001 – 3.957 $\pm$ 0.002
3.	Chromium (mg/kg)	0.307 $\pm$ 0.003 – 7.353 $\pm$ 0.008
4.	Copper (mg/kg)	0.016 $\pm$ 0 – 1.576 $\pm$ 0.001
5.	Cadmium (mg/kg)	0.001 $\pm$ 0 – 0.095 $\pm$ 0.001
6.	Zinc (mg/kg)	2.70 $\pm$ 0.007 – 10.42 $\pm$ 0.01
7.	Lead (mg/kg)	0.87 $\pm$ 0.15 – 2.69 $\pm$ 0.17



**FIG 1: Map of Sombreiro River showing sampling stations**

#### Legend

- Road
- River
- Settlement
- Flow Station
- Mangrove Vegetation
- stations

**SCALE: 1:100,0000**

#### RESULTS AND DISCUSSION

The mean percentage values obtained for sand (70.29), clay (17.31) and silt (12.39) in this study favourably compares with that of Okpoka creek (sand - 73.97%, clay - 22% and silt - 27%) as reported by [11] but with a slight variation from that of [12] (sand - 88.6%, clay - 7.09% and silt - 4.31%) also in the Sombreiro River. This is a result of the fact that the axis of the Sombreiro River

where this present study was carried out and Okpoka creek are brackish and tidal while that of [12] was carried in the fresh lotic water area of Sombreiro River.

Mean concentration of pH in sub -tidal surface sediment of Sombreiro River varied from  $6.61 \pm 0.175$  –  $7.16 \pm 0.03$ . This range of value is closely related to the  $6.9 \pm 0.07$  –  $7.8 \pm 0.14$  recorded

by [13] in a fresh water stream in the Niger Delta as well as that of [14] who posited a range of 6.9 – 7.8. The sediment in these studies are generally alkaline, and is opposed to the acidic pH value of  $2.7 \pm 0.10$  –  $5.5 \pm 0.31$  gotten by [9] in the Rumueme Creek, Port Harcourt, and [12], who reported a range of 5.06 – 5.85 in the Sombreiro River. The alkaline sediment observed in this study as against that of [12] can be attributed to the high level of industrial (oil exploitation including illegal refining of crude) and commercial (transportation by engine boats) activities in this axis of Sombreiro River.

The sediment conductivity of the study area fluctuated from a low of  $4798 \pm 408$   $\mu\text{S}/\text{cm}$  to a high of  $10836 \pm 158$   $\mu\text{S}/\text{cm}$ . This range compares favourably with other studies carried out in brackish water areas such as [9] who recorded a range of  $1867 \pm 116$  -  $12800 \pm 8834$   $\mu\text{S}/\text{cm}$  in the Rumueme Creek. However it is at variance with those carried out in fresh water areas such as that of [13] who reported a mean conductivity range of  $79.0 \pm 1.07$  -  $225 \pm 14.1$   $\mu\text{S}/\text{cm}$  and the range of 40 – 1940 observed by [12] in the Sombreiro River. The wide disparity between the conductivity of the sediment in this study and those of fresh water area is as a result of the differences in ionic content between brackish and fresh water.

The mean total organic carbon (TOC) content of the study sites in the Sombreiro River varied between  $0.87 \pm 0.15$  and  $2.69 \pm 0.17\%$ . This is indicative of high organic carbon content, in line with the position of [15] that sediments with values of organic carbon content exceeding 1% are said to have high organic carbon content. This is comparable to the 2.02 – 4.134% gotten in the Sombreiro River by [12]. Nevertheless it is lower than the reports of previous investigations in which sediment organic carbon in the range of  $2.67 \pm 2.08$  –  $16.00 \pm 5.00\%$ , 17.67 – 32.05% and 9.08 – 28.01% was reported by [16] in the Rumueme Creek, Upper Bonny River; [17] in the main channel of the Bonny estuary and [18] in sites around the upper Bonny estuary respectively. The differences in the value of TOC in these studies may be as a result of levels of bacterial decomposition of organic matter in sediment and or variation in the levels of anthropogenic perturbations in the study sites.

The total hydrocarbon content in sediment of the Sombreiro River during this investigation fluctuated from  $322.5 \pm 155.50$  -

$2178.5 \pm 64.50$  mg/kg. This range is in agreement with the  $400.6$  –  $6205.5$  mg/l reported by [19] in the upper reaches of Sombreiro River. It is however very high when compared to the findings of [13] who recorded a range of  $49.04 \pm 48.20$  –  $412.64 \pm 129.05$  mg/kg in a fresh water stream in the Niger Delta. The FMENV's maximum limit of 30mg/kg THC in sediment/soil is far below the least mean value of 322.5mg/kg in this study. It then follows that the entire stretch of sub tidal sediment in the brackish water axis of Sombreiro River is polluted with petroleum. This observation corroborates that of [19] and [20] who both reported that of all the 5,500 tons of hazardous wastes produced per annum in Rivers State, the petroleum industry, including the refineries (legal and illegal) generates most of them. This equally explains the observed leaf loss or complete defoliation of the characteristic mangrove vegetation (*Rhizophora* and *Avicenna*) in some impacted areas, as well as the near absence of mudskipper and crabs on the mud flats during low tide in the study area. It also poses a great danger to benthic fauna and by extension top predators such as fish and or consumers of marine resources including humans.

Generally, the concentration of THC in this study was higher in the sediment samples than in the surface water samples. This can be attributed to the fact that hydrocarbons being volatile in nature will evaporate the ones at the surface of the river and the remaining will sediment at the bottom of the river thus increasing the concentration in the sediment over time [21].

In this investigation concentration of nitrates in sediment fluctuated between  $1.34 \pm 0.04$  –  $4.0 \pm 0.135$  mg/kg. This range of value is in parity with the  $0.97 \pm 1.12$  –  $6.47 \pm 1.56$  mg/kg documented by [10] in Rumueme Creek, Bonny Estuary. It is however slightly higher than the  $0.62 \pm 0.38$  –  $2.83 \pm 0.13$  mg/kg gotten in a fresh water stream in the Niger Delta by [13]. Concentration of phosphate in sediment of Sombreiro River varied from  $0.39 \pm 0.01$  –  $2.97 \pm 0.03$  mg/kg throughout the period of study. This range of values falls within the wider range of  $0.29 \pm 0.05$  –  $24.4 \pm 10.8$  mg/kg as reported by [13].

The concentration of iron in sediments of Sombreiro River in all 10 sampling Stations throughout the period of study was far above the

Rivers State Ministry of Environment and Natural Resources stated limit of 0.5 – 10mg/kg, ranging from  $114.37 \pm 0.005$  –  $436.82 \pm 0.025$ . This range of value is equally higher than the  $73.00 \pm 29.28$  reported by [10] in the Rumueme Creek of Upper Bonny Estuary. It is however comparable to the range of  $241.69 \pm 2.48$  –  $477.49 \pm 3.94$  recorded by [22] from the lower Sombreiro River, and a little lower than the mean concentration of  $674 \pm 12.31$ mg/kg gotten in Owubu Creek also in the Niger Delta by [23].

In the sediments of Sombreiro River, this study showed that the concentration of lead varied from  $0.025 \pm 0.0$  –  $1.424 \pm 0.002$ mg/kg. This is consistent with the report of [22] who recorded  $0.33$  –  $0.59$ mg/kg as the mean concentration range. The concentration of lead in this present study is however low, when compared to some previous investigations in the Niger Delta, [13] reported a range of  $3.96 \pm 0.37$  –  $37.14 \pm 17.31$ mg/kg and [23] recorded a mean value of 6.22mg/kg.

### Conclusion

The investigation has revealed that the entire stretch of the sediment of Sombreiro River is polluted with petroleum hydrocarbon, and therefore needs urgent clean up and or restoration in order to avert loss of biodiversity, loss of means of livelihood and health hazards for the locals.

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